A Ph.D. synopsis

on

Study on the effect of plasma treated banana fiber and fabric on calorimetric and fastness properties

Submitted by

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Self declaration

The research scholar is solely responsible for the contents of the papers compiled in this research proposal. The topic of the research has been prepared after through literature review of many research articles. The references of these articles have been provided in the reference section of this proposal. If there are any errors that are purely unintentional, this may be corrected if it is pointed out.

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II

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1. INTRODUCTION

Banana plants are a member of the Musaceae family and are indigenous to Indonesia and Malaysia in South-East Asia. In tropical and subtropical nations around the world, banana production is widespread and they are a valuable natural resource [1–3]. From a practical standpoint, banana plants are regarded as among the most significant plants in the world. Almost all of this plant's parts, including the fruit, peel, leaves, pseudo-stem, stalk, and flowers, are useful [3, 4]. They are utilised in a variety of food and non-food applications, such as textiles, cattle feed, bioactive component sources, thickeners, dyes, flavours, and organic manures [4]. Additionally, the banana pseudo-stem has been utilised as a source of raw materials for pulp and paper, textile fibre, and filler or structural reinforcement in composite materials. [5–10].

Abaca (Musa textiles) is a kind of banana plant famous for its fibre. [11]. The banana plant's pseudo-stem is the stem that carries nutrients from the soil to the fruits. After the banana fruit has ripened and been picked, these pseudo-stems are trimmed and turned into garbage. [1, 11, 12].

Banana fibres are an example of a natural fibre that has several benefits over synthetic fibres. They may be extracted from the waste of the banana plant and are inexpensive, abundant, renewable, and sustainable. Banana fibres and other lignocellulosic fibres have very better tensile strengths as well. The removal of lignin, gum, and other contaminants that negatively impact the softness and dyeability of banana fibres is the main challenge to be overcome during chemical processing. [13] To remove impurities, enhance softness, dyeability, etc., textiles can undergo a variety of chemical treatments, such as alkali treatment and silicone finishing [14]. However, the amount of water and chemicals needed for these chemical treatments end up harming the ecosystem. Other surface treatments, such as the application of plasma to the textile to eliminate impurities and improve softness, are available to address this issue. These treatments don't need water, use less energy, and are environmentally friendly.[15]

In the following literature study, an effort has been made to examine the cutting-edge and environmentally beneficial research area of banana fibre and plasma treatment. This part examines numerous potential uses for banana fibres and plasma treatment using the research literature that is currently available.

2. LITREATURE REVIEW

2.1 Pseudo-stem fibre from banana plant

One of the parts of the banana plant that resembles a trunk is the pseudo-stem, which is made up of a soft central core and up to 25 leaf sheaths. When these leaf sheaths reach maturity, they separate from the stem and change into recognizable banana leaves. The banana plant can grow as tall as 7.5 metres, and because the leaf sheaths develop from the plant's base, some of the leaves' inner sides are about the same length as the tree. Conversely, the later-growing, shorter outer side leaves. The banana leaves can stretch up to 30 centimeters in width. [16]

2.1.1 Production of fibre from banana pseudo stems

Pseudo-stem fibre from the banana plant is slightly more elastic. The main applications for banana pseudo-stem fibre are the production of specialised and premium sanitary goods like newborn diapers, textiles, and papers like banknotes. Since the banana pseudo-stem fibre has strong resistance to sea water and buoyant capabilities, it can also be utilised for ropes like marine rope. This fibre can also be used to make disposable fabrics, light-density woven fabrics, filter cloths, plaster reinforcing fibres, coffee and tea bags, and disposable clothing. The literature claims that the global production of abaca (Musa textiles) fibre has surpassed 100,000 tonnes per year. Abaca output peaked in 2002 at about 99,320 tonnes per year, compared to a similar level in 1960 (about 97,000 tonnes per year). Figure 1 depicts the percentage of bananas produced globally in 2010.

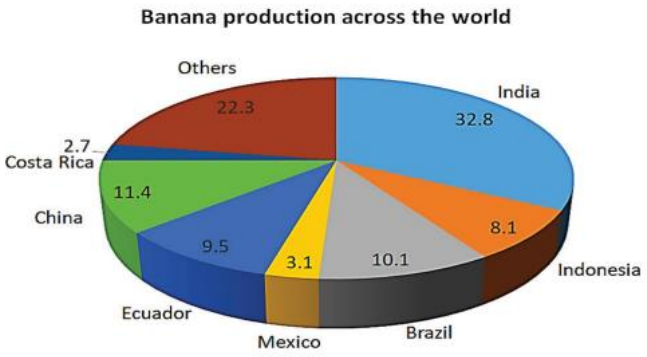
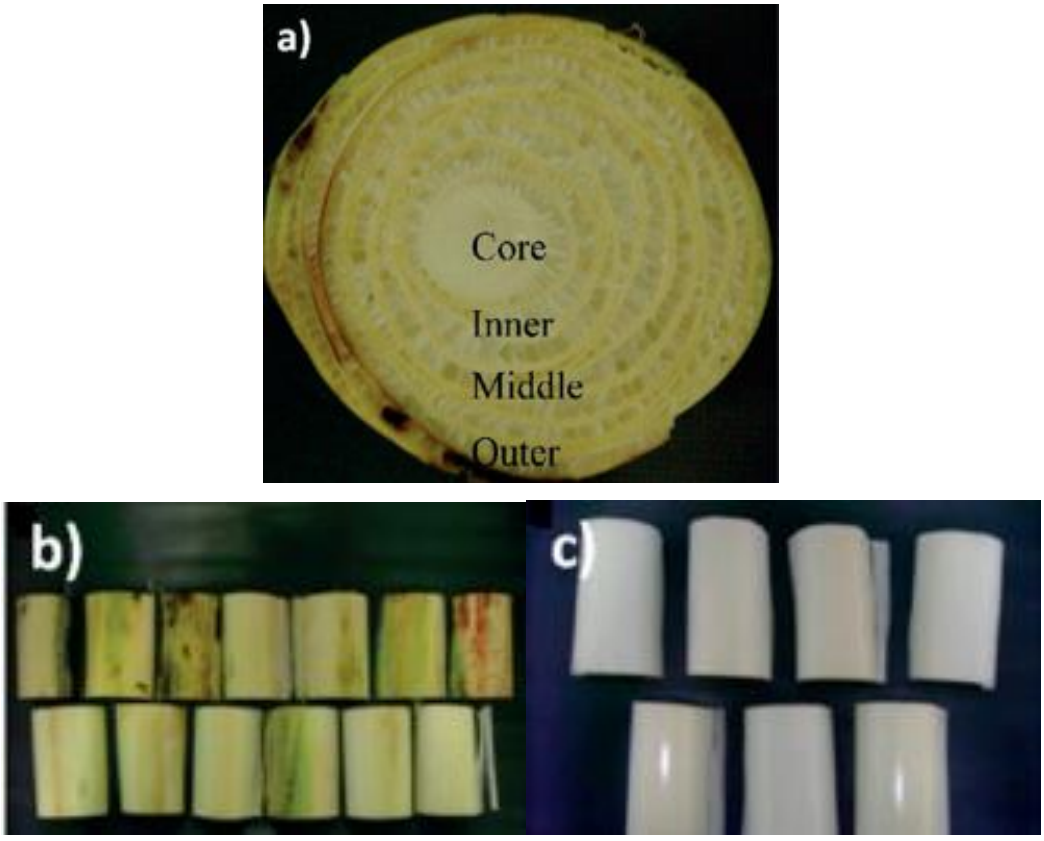


Figure 1: Data on the percentage of bananas produced worldwide in 2010 [17]

2.1.2 Plantation and harvesting

The pseudo-stems of the banana plant, which have a shallow roots system, grow vertically. A single plant may develop up to 25 of these pseudo-stems, each of which matures at a different period. The outer pseudo-stems of the plants are ripe and ready for harvesting by the time they are 18 to 24 months old. Then, depending on how quickly the pseudo-stem is growing, three or four pseudo-stems are removed over a period of six to twelve months. The pseudo-stems are totally ready for harvesting when the flower is comes out. Additionally, the pseudo-stems are cut at the base after the shaft is severed below the flowering part with a knife or sickle connected to a long pole. The pseudo-stems can either be defibered/extracted of their fibres in situ or by utilising a decorticating machine, depending on the extraction procedures [16]. The length of the leaves varies, with the leaves on the outer side being shorter than those on the inner side. The cross section of the banana pseudo-stem and its components are shown in Figure 2.



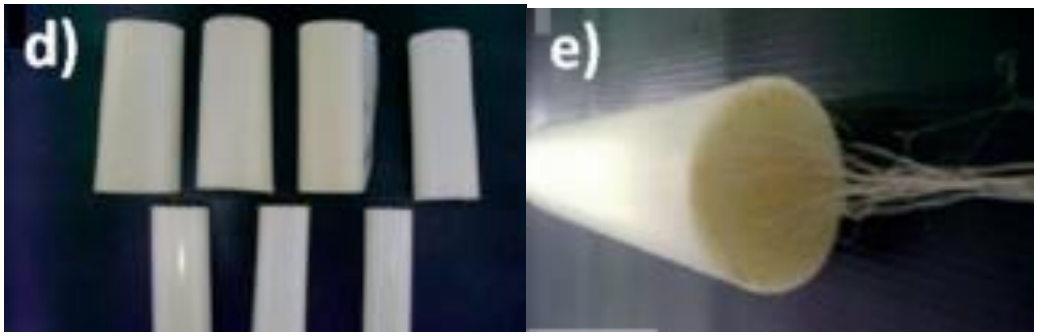


Figure 2: (a) Cross section of a banana pseudo stem trunk and its components (b) Exterior parts (c) middle parts (d) interior parts (e) core parts [18]

2.1.1 Fiber extraction

A decorticator machine can be used to separate the fibres from the leaves of the banana pseudo-stem. It is a device used to remove grain, stalk, skin, bark, and wood. Once the leaves of the pseudo-stem have been chopped, the extraction procedure has begun. The most widely used technique combines water retting and scraping. Tuxing is the first stage, which involves separating the fibre bundles from the other components. Both manually and mechanically using a machine, one can do tuxing. The clipped pseudo-stems are stripped of their leaves. A knife is then inserted between the outer and middle layers of the leaf shaft at the butt end, and the outer layer is peeled out while being kept securely in place. This tuxing process produced fibre bundles that were around 5-8 cm wide, which is equal to the length of the leaf. After the tuxing process, the second step is to remove any remaining gum or non-fibrous materials from the fibres. [16]. The fibres are also completely washed and dried after that. These procedures require a lot of skill and competence. Only 11 outer leaf sheaths of the pseudo-stem can be extracted for its fibres. Due to their brittleness and low strength, the fibres present inside are difficult to peel. [19].

Figure 4 depicts the decorticator machine's schematic diagram. The decorticator device consists of a shaft-mounted revolving drum. Numerous blades installed around the drum's circumference provide a beating action as it is rotated by an electrical drive. The pseudo-stem is fed between the drum and backing plate or feeding roller as the drum turns. Crushing, pounding, and pulling forces cause the pulpy material to be removed halfway

through. The fibres are eventually gathered on the bucket after the pseudo-stems are gradually pushed out of the drum and fall on the conveyer belt.

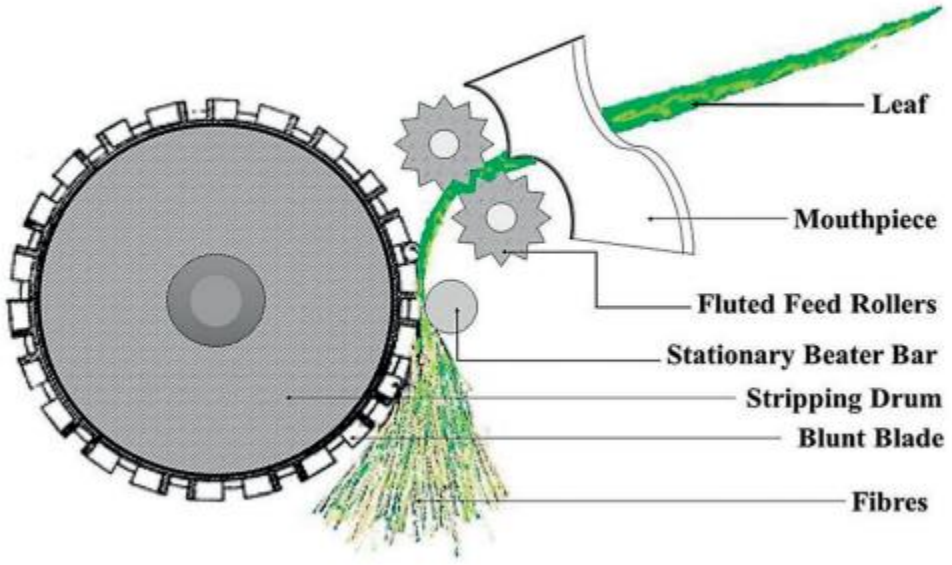


Figure 3: Pseudo stem fiber extraction machine[13]

The fibres are then degummed to get rid of any foreign objects, cleaned, and dried at room temperature, which is roughly 27–32°C. This machine has a daily capacity of around two tonnes of dry fibre.

Banana pseudo-stem fiber retting

Retting of banana fibre is the process of separating the fibre bundles from the cortex or wood, which results in a partial digestion of the materials that bind the fibre bundles together (such as lignin and hemicellulose). The loss of various cementing tissue components is another factor contributing to the loosening of the fibre bundles. The retting of banana fibre takes place in two steps, similar to the normal retting procedure. The physical absorption of the water is the initial stage; swelling follows, and some of the soluble components are removed. The second stage is the microbial stage, which can be either aerobic or anaerobic depending on whether bacteria or fungi are involved. Since the retting process primarily involves microorganisms, it depends on a number of variables, including macronutrients, microbiological agents (bacteria or fungi), and the

water's composition. Typically, microbial growth on plant fibres causes tenacity loss, odour release, and different forms of strains on the substrates of the fibres. On occasion, a certain microbe can develop on the stem of a living plant and cause reddish stains on the fibre that are typically referred to as rust. Temperature, retting time, chemical additive type (such as magnesium oxide), and pure cultivation of microorganisms like pectin-decomposing bacteria in the retting liquor can all significantly shorten the retting time by up to 78%. The pseudo-stem retting time of 28 hours was discovered to be more than adequate, and the procedure worked well at room temperature and a regulated pH of 6.8 to 7.4 with sodium carbonate.[13] To improve the mechanical qualities of natural fibre, such as banana pseudo-stem fibre, retting is used[20]. Analysis of decorticated and retted pseudo-steam fibers indicated that retting can dramatically decrease the hemicellulose and lignin that are present in the pseudo-stem fibre [21].

2.1.2 Banana pseudo-stem fiber degumming

Gum and non-fibrous cells or parenchyma make up a sizable portion of the banana pseudo-stem fibre made by the decorticator machine (about 30-35%). Before the fibre is physically spun into fine yarn count, these gums and cells must be removed because they are typically not soluble in water. It is a numerical term that describes the thickness and fineness of the yarn. Mass per unit length or length per unit mass of the yarn is the unit of count. The main components of these gums are arabans and xylans, both of which are soluble in alkaline solutions. The basic steps in the degumming process are as follows: boiling the fibres twice in an aqueous alkaline solution with/without pressure, agitation, and reducing agents; washing them to neutralise; bleaching them with dilute hydrogen peroxide or hypochlorite; and finally, washing them to neutralise and oiling them with a sulfonated hydrocarbon. Caustic soda is used in the majority of procedures to remove any remaining pectin, lignin, or gum. [13].

2.2 Properties of banana pseudo-stem fiber

2.2.1 Morphological properties

The pseudo-stem fibre of the banana plant under optical microscope was found to be multicellular, just like other bast fibres. After coating the banana pseudo-stem fibre with a

small layer of gold or iridium, scanning electron microscopy was used to examine the structural and fracture morphology which is given below. [13].

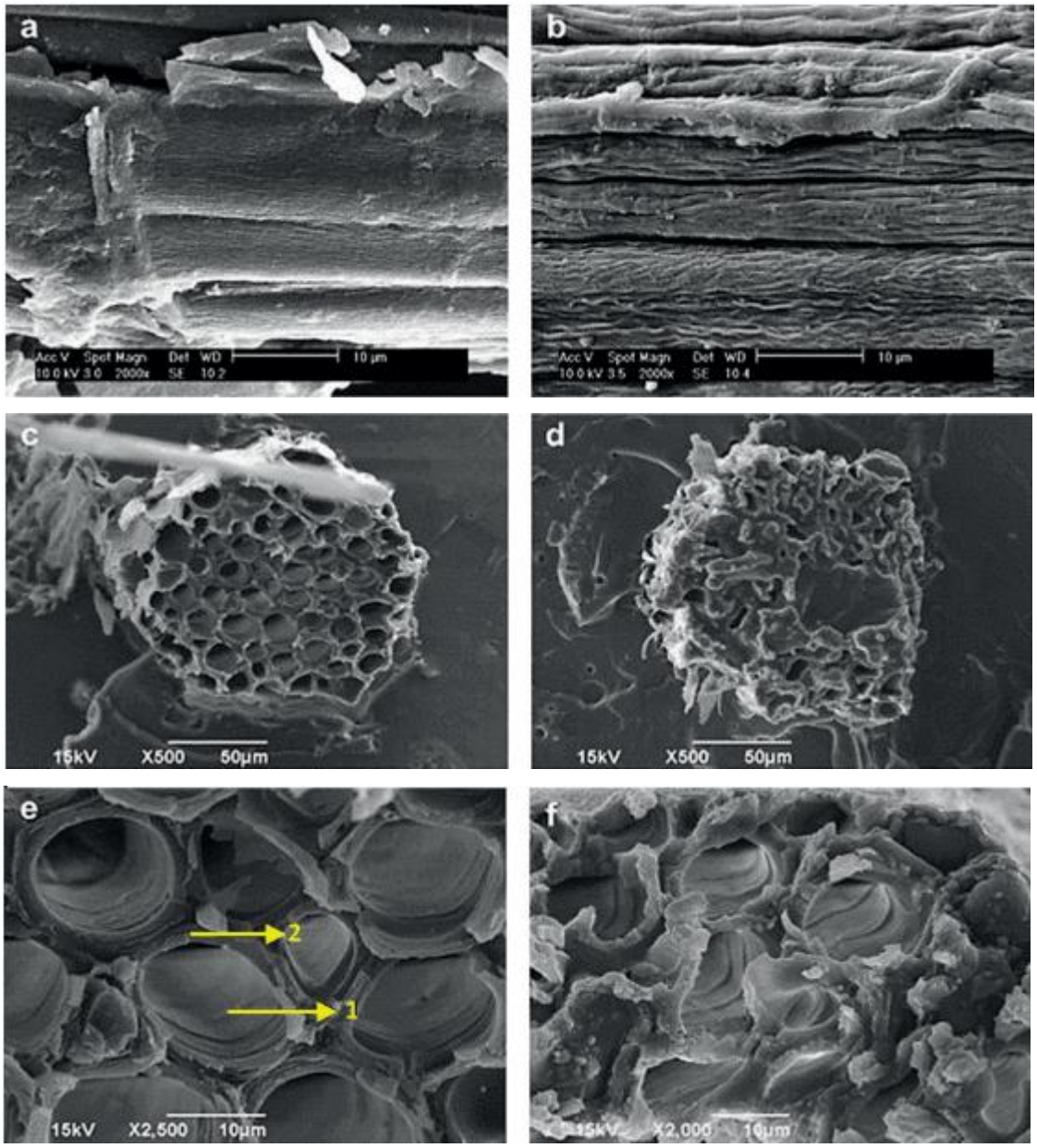


Figure 4: SEM images of banana pseudo stem fiber [13]

As seen in Figures 4a and 4b, banana pseudo-stem fibre has a scaly, cellular structure with intact vegetable materials. The fibers' bundle structure, in which each bundle is made up of many fibrils, is responsible for the horizontal marks on the fibre surface. Figures 4c and 4d show the transverse section of the pseudo-stem fibre, confirming its multicellular structure, while Figures 4e and 4f depict the raw fiber's structure. As seen in

the image, the fiber-cell walls (marked by arrow no. 1) and lumen (marked by arrow no. 2) are both clearly visible in the cross section.

The banana pseudo-stem's hollow structure suggests that the fibre will have high insulating and absorption qualities. Alkali treatment of the fibre may produce fibres of high grade. For instance, treatment of pseudo-stem fibre with various NaOH concentrations revealed that the surface morphology of the 5% NaOH-treated fibres was hardly different from that of the untreated fibres. Despite the fibre not being clearly visible, the surface appeared clearer as some impurities and dirt were removed. When the pseudo-stem fibre was exposed to 10% NaOH, the fibres and their fibrils were clearly evident. [13]

2.2.2 Physical and mechanical properties

The physical, chemical, and other qualities of banana pseudo-stem fibres make them high-quality fibre. In terms of mechanical properties, banana pseudo-stem fibre has been described as having good stiffness, tensile strength, and elastic modulus, which makes it a potential textile material. [1]. Although banana pseudo-stem fibre looks quite similar to ramie and bamboo fibre, it has far superior spinnability and fineness than ramie and bamboo. It has an average fiber length of 24 to 36 inch and an average fineness of 6 tex to 12 tex. It has a low strain at break and is a strong fibre. It has a shiny appearance which depends upon its extraction and spinning procedures. It has a high moisture absorption capacity (10%) and a low density (1.35 g/cc). It quickly absorbs moisture and quickly releases it. [22]

Banana pseudo-stem fibre possesses a high degree of crystallinity and a spiral angle of roughly 15°, according to X-ray investigations findings. The molecules are closer together in the crystalline area. The banana pseudo-stem fibres that had been acid and alkali treated displayed more amorphous regions than the untreated fibre. [23]

2.2.3 Durability and biodegradability[13]

The Centre of Study for Natural Fibre and Natural Dyes (CSNFD) of the Department of Chemical Engineering, Universitas Islam Indonesia (UII), has conducted studies on the durability of banana pseudo-stem fibre. According to the study, banana pseudo-stem fibre

can withstand storage for up to three months. The strength of the fibre, however, is significantly reduced if it is stored for more than three months.

Banana pseudo-stem fibres can also be categorised as harmless to the environment because they are biodegradable. Almost any spinning technique, including open-end spinning, ring spinning, bast fibre spinning, and semi-worsted spinning, can be used to create banana pseudo-stem fibre. By burying the fibre in the ground, the biodegradability of the pseudo-stem fibre from bananas can be studied. Microorganism development contributes significantly to the cellulose fiber's destruction by the production of the cellulose enzyme when buried in the ground, which causes tenacity to be reduced. According to the results of the soil burial test, the banana pseudo-stem fibre rapidly loses strength when buried in the ground. Compared to sisal and jute, which experience decreases in tensile strength of roughly 65.8% and 78%, respectively, after being buried in soil for three days, only about 21.8% of fibres exhibit this phenomenon. The decrease of fibre strength may be attributed to water molecules penetrating the multicellular lignocellulose fibres in banana pseudo-stem fibres under certain elongation circumstances. Cell slippage occurs when load is applied as a result of the fibres swelling up and, to some extent, the binding of the ultimate cells becoming looser. Extension of untreated and degummed fibres is decreased by 6% and 11%, respectively, under wetting circumstances. [13]

2.2.4 Thermal properties

To examine the heat stability or thermal degradation of banana pseudo-stem fibre, thermogravimetric analysis (TGA) is used. With a resolution of 0.1 mg, the TGA analyzer measures weight loss as a function of temperature. The fibre samples, which weighed between 3 and 6 mg, were dispersed at random in the sample pan. To guarantee the consistency or repeatability of the TGA result, a limited amount of sample was used. The following is a TGA of a banana pseudo stem example. At a heating rate of 10°C/min between 25°C and 700°C in a N_2 atmosphere, the thermal deterioration of the fibre began. The fibre from the banana pseudo-stem underwent three stages of thermal breakdown. The initial stage of degradation involved moisture evaporation at 30-144°C temperatures. [24]. The weight of the fibre reduced as a result of the release

of moisture and certain volatile extractives as the fibre was heated continually. However, because of the fiber's structural resistance and hydrophilic nature, the moisture that is trapped inside the fibre cannot be entirely expelled. The fibre lost between 5% and 10% weight in this initial stage. Hemicellulose degradation was the second stage. At a temperature of about 178°C, the hemicellulose in banana pseudo-stem fibre began to break down [24]. The presence of acetyl groups, which cause the hemicellulose to disintegrate considerably more quickly than the other components, such as lignin and cellulose, is probably the cause of the hemicellulose's reduced stability. Cellulose breakdown took place in the third stage at a temperature of roughly 296°C. The final stage, or fourth stage, is the breakdown of lignin. Lignin is more difficult to break down than other substances. For all plant fibres, Lignin generally decomposes slowly in all temperature ranges up to 700°C.

2.2.5 Chemical properties

According to research, plant fibres include some of the following elements.[31]

1. Fat and wax, primarily present on the surface of plant fibers
2. Pectin, a calcium and magnesium salt of galacturonic acid that is available in a water-soluble form.
3. Hemicelluloses, which are made up of amorphous short-chain polysaccharides and polyuronides. The polysaccharide hemicelluloses are chemically connected with cellulose molecules.

4. Cellulose, which is the main component of the fiber.

5. Lignin, which is short-chain isotropic and amorphous polymer composed of units derived from phenyl propane.

6. Ash content.

7. Aqueous extract, which is obtained by boiling the scoured fibers in water.

Table 1 shows the composition of components of banana pseudo-stem fiber based on literatures [25].

Sample	Cellulose	Hemicellulose	Lignin	Ash Content	Others	Moisture content
1	63.20%	18.60%	5.10%	1.02 %	2.08%	10.00%

The banana pseudo-stem primarily consists of cellulose, as seen in the table. There are several ways to extract cellulose fibres from their biomass sources, including liquefaction, alkali treatment, steam explosion treatment, and enzyme treatment. [23]. The alkali treatment procedure is among the most frequently utilised techniques. Studies have been done on the fibre from alkali-treated banana pseudo-stems. [13] The 18% NaOH treatment of the fibre has improved the fiber's breaking elongation. This caustic treatment also caused length shrinkage. The maximum shrinkage was observed within 20 minutes of the alkali-treatment, and then there was only very little shrinkage. It has been discovered that the length reduction is directly related to weight loss. The elimination of the hemicellulose component and other components via caustic treatment is the primary cause of the weight loss. However, the dynamic modulus of the banana pseudo-stem fibre similarly decreased after an alkali treatment. This decline can be due to structural modifications brought on by alkali treatment. The caustic treatment led in a 15–100% increase in fibre diameter, which improved bulk of the bundle fibre.

The removal of lignin, leftover gum, and other cementing components, which interfere with the absorption property and therefore results in poor scouring, bleaching, and dyeing of the fibre, is the main issue to be met during wet processing of banana pseudo-stem fibre. Though it is commonly accepted that lignin is a three-dimensional polycondensate of dehydrogeneration products of hydroxy and methoxy cinnamyl alcohols, its specific structure is not known. Methoxyl, hydroxyl, and carbonyl groups make up the majority of lignin's chemical structure. [13]

The fibre from the banana pseudo-stem's physico-chemical characteristics were also investigated. One of the most popular instrumental techniques for examining the physico-chemical characteristics of textile materials is infrared (IR) spectroscopy. When infrared radiation passes through an organic compound sample, some frequencies are absorbed while others are transmitted through the sample. By graphing the percentage transmittance or absorbance values against the frequencies, the IR spectrum can be derived.

2.3 Plasma Treatment on Textile Substrates

The use of plasma in textile modification offers a huge opportunity for advancing from a more traditional, energy-intensive, slow and environmentally damaging treatment techniques. Utilising plasma in textile chemical processing is environmentally beneficial and lowers production costs because it uses less energy and processes more quickly. Plasma treatment also provides the opportunity to obtain textile finishes without altering the essential textile characteristics. The current review aims to provide a comprehensive overview of plasmas for textile treatment.

2.3.1 Introduction to plasma:

Plasmas are composed of ionized gases [26]. Typically, a gas acts as an electrical insulator. However, if a gap containing a gas or gas mixture is exposed to a sufficiently high voltage, the gas or gas mixture will disintegrate and conduct electricity. The electrically neutral atoms or molecules of the gas are ionised, or divided into positively charged ions and negatively charged electrons. The resulting ionised gas is called as a discharge or plasma. The specific physical and chemical characteristics of the plasma environment are produced by the interactions of the electrically charged particles with one another, with the neutral gas, and with contact surfaces. Plasmas are sometimes referred to as the fourth state of matter because of the environment they exist in, which is different from that found in solids, liquids, or gases [27].

The ionisation of gases can be induced in numerous ways. They are:

(1) Glow discharge

Glow discharge, the oldest type of plasma technology, which is created at low pressure, gives highest level of consistency and flexibility as compared to other plasma treatment.

(2) Corona discharge

By applying a low frequency or pulsed high voltage over an electrode pair, the configuration of which can take on a variety of forms, corona discharge is created under atmospheric pressure.

(3) Dielectric Barrier discharge

An electrode pair with at least one covered by a dielectric substance is exposed to a pulsed voltage in order to create a dielectric-barrier discharge.

(4) Atmospheric pressure plasma technique

An unique, non-thermal, glow-discharge plasma that operates at atmospheric pressure is the Atmospheric Pressure Plasma. [28].

2.3.2 Plasma's significance in textile applications

In the past decades, strict environmental regulations, particularly in developed nations, have compelled businesses to address environmental issues and think beyond the problem of industrial wastes to possible replacements for traditional processes that could offer equivalent or even higher efficiency and less negative environmental effects. Toxic, dangerous, and poorly biodegradable compounds and auxiliary materials are used in a wide range of textile industry sectors, making it difficult to solve the environmental issues in this. A few examples of the complex environmental impact of textile processing include high water and energy consumption, high oxygen demand of some input materials used, and the production of enormous amounts of effluents with high chemical oxygen demand (COD), excessive colour, pH, and toxicity. [29]. Although still primarily on a scientific level, the textile industry is progressively catching on to the benefits and interest that plasma processing has generated in the creation of microelectronics, the automotive industry, biomedical applications, and the modification of polymers. [30]

The plasma treatment of textiles has several practical, economic, and environmental advantages. The ability to modify many types of fibres (natural protein and cellulose, synthetic), textile forms, and product functional design using a single system is a reflection of plasma processing's versatility. [31]. In order to deliver intrinsic effects on textiles, the right choice of gas (O_2, N_2, H_2, air, Ar, He, NH_3, hydrocarbons, fluorocarbons) and management of the plasma operating conditions (treatment time, power, pressure, gas flow rate) are necessary. Since the fibre surface is primarily responsible for the bulk of the end-use qualities of textile products, the alteration of the fibre surface is an important step in many processes and applications. [32]. Additionally, the confinement of plasma treatment to the fibre surface, which preserves the bulk properties, seems to make it particularly convenient [33].

There are two different forms of plasma that can be applied to textiles: atmospheric pressure and vacuum pressure. While atmospheric pressure plasma creation has been the subject of many investigations, low-pressure treatment provides far superior stability, control, and reproducibility. [34]

Some writers divide vacuum pressure plasmas into low and medium pressure subcategories. Both of these forms can be applied to textiles, and research is still being done to discover how they will affect textiles [34].

2.3.3 The importance of low temperature plasmas in the treatment of textiles:

The majority of low-temperature plasma (LTP) or cold plasma is created by glow discharges in gaseous environments. A crucial characteristic of this kind of plasma is that the temperature of the electrons and the energy of the unionised gas particles are not in equilibrium. This makes it possible to create situations where the plasma gas's temperature stays near to that of the surrounding air while the electrons' energy is adequate to break covalent and intermolecular bonds. LTP has the ability to initiate modifications in polymers that are not heat-resistant, which includes nearly all fibre-forming polymers. [34]. Extremely high gas temperatures (Thermal Plasma) can only support extremely high plasma densities (more than 1013 electrons cm^{-3}). Because the energy of the plasma will burn practically any material, this exceptionally high degree of plasma density is inappropriate for treating textiles. Thus, the plasma must operate at room temperature to process textiles, giving rise to the term "cold plasma." Cold plasma also has the advantage of chemically treating fabrics and other substrates without harming them with high temperatures.

2.3.4 Influence of plasma treatment on various types of natural cellulosic fabrics:

Influence of plasma treatment on cotton fabrics

The most commonly used natural fibre, cotton, has undergone a great deal of plasma treatment testing. PVA sizing substance has been taken out of cotton garments using atmospheric plasma. It has been reported that plasma treated cotton could entirely remove PVA sizing material with a straightforward cold water wash, in contrast to conventional treatment, which requires hot water for effective removal of size. Under low pressure, O_2 plasma treatment has been proven to enhance the scouring and dyeing behaviour. [35].

Sun et al [36] studied the impact of low pressure plasma treatment on cotton fabric dyeing. They discovered that attachment of surface polar groups makes cotton more wettable, which enhances dye absorption and scouring. Better treatment follows from better adsorption.

According to SEM analysis of the cotton fibres, the plasma-treated cloth features pores on the surface that act as entry points for dye molecules, improving dyeing rates. The plasma's ablation effect, which is characterised by holes, may have increased the surface area of the fibre. This, together with the improved wetting brought on by the attachment of surface polar groups, may have resulted to an increase in dyeing rates.

Investigations into the effects of DC air plasma and cellulase enzyme treatments on the hydrophilicity of cotton fabric samples revealed that these treatments were successful in enhancing the hydrophilicity of cotton fabrics. The physico-chemical changes brought on by plasma and enzyme are what are responsible for this rise in hydrophilicity [37]. Shujing Peng et al. [38] investigated the impact of argon/oxygen atmospheric dielectric barrier discharge (DBD) treatment on desizing and scouring of cotton fabric for removal of polyvinyl alcohol (PVA). The capillary heights of fabrics treated with plasma grew dramatically as the plasma treatment time increased, according to wick-ability analysis. Navaneetha et al., [39] studied on the hydrophilic enhancement of grey cotton fabric by low pressure DC glow discharge air plasma and came to the conclusion that the development of polar groups on the fabric's surface was what caused the rise in hydrophilicity. Plasma treatment can be used to make cotton fabrics water repellent by adjusting the application gases. Hexamethyl disiloxane gas treatment of cotton fabric can be used to smooth the surface of the fibres and can increase the contact angle on the fibre up to 130°. Similar to this, fluorine groups can be added to the surface of the fibres using hexafluoroethane plasma to provide a potent water repellency effect. Neither of these techniques lessens cotton's capacity to transmit water vapour. [34]. It was also claimed that cotton fabrics might produce the lotus effect with plasma treatment. The basic idea is to etch the fibre to produce nanoscale peaks, which are subsequently covered with a hydrophobic coating using a suitable gas, like hexafluoroethane. The impacts of air and argon atmospheric plasma treatments on different physical properties of bleached cotton

fabrics, including pilling propensity, friction coefficient, thermal comfort, water vapour permeability, and surface properties, were examined. [40]. CF_4 and C_3F_6 were applied to cotton denim fabrics by McCord's research team at North Carolina State University using a low-pressure, low-temperature plasma system to boost the water repellency characteristics of surface. [41].

Influence of plasma treatment on flax and hemp fabrics:

The observed increase in water retention and wetting rate of flax is explained by the fiber's improved receptivity to water molecules as a result of plasma etching and plasma oxidation, which result in the production of new carboxyl groups [42]. The effect of low-temperature plasma (LTP) of hemp has been investigated [43]. Radetic, [44] examined how hemp's dyeing abilities were affected by low-temperature air plasma and enzymatic treatment. In addition to determining dyeing kinetics, colour yield, and colour fastness, measurements of weight loss, water retention, and degree of whiteness were made, along with SEM analyses of samples that had been subjected to various treatments. Hemp cloth was subjected to low-temperature plasma treatment, which increased the dyeing rate, total dye exhaustion, and colour yield of dyed samples. Plasma etching and oxidation effects on the surface of the hemp fibre were used to explain the beneficial effects of the treatment. According to the findings, samples that had been treated with enzymes and low-temperature plasma had even lower final exhaustion and dyeing rates than all other samples. This might be explained by a more pronounced digestion of the fiber's amorphous regions, which after plasma etching were much more easily accessible to enzymes. Plasma etching probably improved fibre porosity and brought about minute topographical modifications that made hemp fibre more permeable to dye and water molecules. Increased dye exhaustion is not solely due to the easier dye penetration into the fibre brought on by plasma treatment; it is also significantly impacted by the structure, molecular weight, and state of the dye in the dyeing bath [45].

Influence of plasma treatment on banana fiber:

3. Rationale of this research

Banana is the second most valuable fruit crop in India next to mango. Its availability throughout the year, low cost, variety, flavour, nutritional content, and therapeutic value make it a favoured fruit among all socioeconomic groups. But, there are roughly 4 tonnes of biomass wastes (such as leaves, pseudo-stems, etc.) produced for every tonne of banana fruit collected. Thus, four times as much trash is produced during each banana fruit manufacturing cycle. [12]. A banana farm can generate roughly 220 tonnes of garbage per hectare[11]. The farmer either disposes of these pollutants in water sources or just incinerates them. If banana plant waste is not correctly managed, it could harm the environment because if it is burned or disposed of in wet conditions, it could release greenhouse gases that could be very harmful to the ecosystem. [11]. Using this crop waste as a source of cellulosic fibre for additional uses, such the creation of yarn and fabric, is more reasonable. [9]. The benefits of banana fibres include due to their excellent tensile strength. In Madhya Pradesh, plenty of banana plants are produced that can be used scientifically to make value added textile materials. The removal of lignin, gum, and other contaminants that negatively impact the softness and dyeability of banana fibres is the main challenge to be overcome during chemical processing. To get rid of impurities, to enhance softness, dyeability, etc., textiles can undergo a variety of chemical treatments, such as silicone finishing and alkali treatment. However, the amount of water and chemicals needed for these chemical treatments end up harming the ecosystem. Other surface treatments, such as the application of plasma to the textile to eliminate impurities and improve softness, are available to address this issue. Plasma processing is a dry and environmentally safe process. It does not need large amount of water, heating and drying, and very small amounts of chemicals are needed to improve the desired functional property. The bulk properties of the material, such as its mechanical strength, are

unaltered because the desired material behaviour is achieved by altering only the fibre surface. In other words, plasma treatment enables the modification of surface properties without modifying the bulk properties of textile materials.

This research proposal is a step to counter this abovementioned problem of reducing the waste generation from banana plant through converting them to value added product like textile fiber as well as fabric for diversified end use and reducing the water and chemicals used in conventional chemical processing treatment by switching over to plasma treatment to improve the wettability, dyeability and colour fastness of banana fabric which can add a tremendous value to the banana fabric produced from the waste of banana plant.

4. Objective of the Study

From the above mentioned literature review the objective of the present study has been set to reduce (study) the waste generation from banana plant through converting them to value added product and reducing the water and chemicals used in conventional chemical processing treatment by switching over to plasma treatment to improve the wettability, dyeability and colour fastness of banana fabric.

So, to attain this objective, following goals are framed.

1. Characterization of banana fiber, yarn and fabric samples
2. Application of plasma on banana fiber sample and banana fabric sample
3. Study on the effect of plasma treatment on colour strength of banana fiber and fabric dyed with natural dye
4. Study on the effect of plasma treatment on Light, washing and rubbing fastness properties of banana fabric dyed with natural dye

5. Materials, Machines and Methods

5.1 Materials

5.1.1 Fiber :

1	Fiber type	Banana fiber
2	Manufacturer	Mangalam Kalpataru Industries, Burhanpur
3	Banana plant variety	G9
4	Place of cultivation	Burhanpur
5	Fiber length	60-95 cm
6	Fiber Fineness	14-17 Tex

5.1.2 Dyes and Auxiliary Chemicals:

- Sodium hydroxide (NaOH)
- Sodium carbonate (Na_2CO_3)
- Wetting agent
- Non ionic detergent
- Hydrogen Peroxide (H_2O_2)
- Sodium silicate
- Indian madder natural dye
- Myrobalan
- Aluminum potassium sulphate
- Acetic acid

5.2 Machines

- Fiber fineness tester (Beesley Balance)
- Hot air oven
- Jute carding machine
- Jute Drawing machine
- Jute spinning machine
- Sectional warping machine
- Handloom

- Water bath for Scouring, bleaching and dyeing
- Spectrophotometer for evaluation of colour strength
- Xenotest for testing of light fastness
- Launder-o-meter for testing of washing fastness
- Crock Meter for testing of rubbing fastness
- RF based capacitively coupled plasma system

5.3 Methods

5.3.1 Fibre Characterization

The following parameters will be analyzed for the characterization of fibre.

(i) Fibre length : Physical Scale Measurement

(ii) Fibre fineness : Beesley Balance

(iii) Fibre strength : Instron Tensile Strength Tester

(v) Moisture content and moisture regain of fiber

5.3.2 Conversion from fiber to yarn

5.3.3 Yarn Characterization

The following parameters will be analyzed for the characterization of yarn.

(i) Count

(ii) TPI

(iii) Tenacity

(iv) Elongation

5.3.4 Conversion from yarn to fabric

5.3.5 Fabric Characterization

The following parameters will be analyzed for the characterization of fabric.

(i) Warp count

(ii) Weft count

(iii) Ends/inch

(iv) Picks/inch

(v) GSM

5.3.6 Plasma treatment on banana fabric samples

Plasma treatment using air, N_2 and O_2 using different power(watt) and time period

5.3.7 Scouring and bleaching of banana fabric samples

5.3.8 Dyeing of treated and untreated banana fabric samples

5.3.9 Evaluation of colorimetric and Fastness properties of dyed banana fabric

(i) Colour strength and colour difference

(ii) Light, washing and rubbing fastness

6. Plan of Work:-

S. No.	Experimental work	Duration
Stage 1	1-Characterisation of banana fibers 2- Scouring and bleaching of banana fiber	6 months
Stage 2	1- Application of plasma treatment on banana fiber 2- Dyeing of untreated and plasma treated banana fiber with Indian madder natural dye 3-Comparision of colorimetric properties of untreated and plasma treated banana fiber	6 months
Stage 3	1-Banana fabric manufacturing 2-Characterization of banana fabric	6 months
Stage 4	1- Scouring and bleaching of banana fabric 1-Application of plasma on banana fabric	6 months
Stage 5	1- Dyeing of untreated and plasma treated banana fabric with Indian madder natural dye 2- Comparison of colour strength, colour difference and fastness properties of untreated and plasma treated banana fabric	6 months

7. Impact of the Proposed Research Work in the Field of Science and Technology as Well as on Society.

Environmental factors are being taken into account on a global scale. Every manufacturing facility is being compelled to switch to a greener technology by rules that have been innovated by various governing bodies throughout the world and environmental awareness among the population. In this paradigm shift textile manufacturing is also included. The world now is dealing with serious environmental issues such pollution, ozone layer depletion, the greenhouse effect, and last but not least, garbage disposal issues. Synthetic fibers are made from the petroleum byproducts which have adverse effect on environment as well as human being. Additionally, as chemical processing uses a lot of water, it is certain that major environmental contamination and health issues will result from discharging waste water containing chemicals into the environment following chemical processing. Therefore, encouraging the use of natural fibres in the textile industry will undoubtedly be advantageous because it will assist to reduce environmental issues, preserve ecological balance, and ultimately benefit society. Our research is on manufacturing of banana fabric from banana pseudo-stem fiber which is totally ecofriendly and obtained from natural renewable resources. Moreover this study is modify banana fiber, spinning, weaving and chemical processing of banana fiber and application of plasma on banana fabric to modify the surface characteristics and improvisation of calorimetric and fastness properties. After successful completion of the project, a new process for manufacturing fine quality banana fabric will be emerged which will increase the profitability of the people involved in the agriculture of banana plant, extraction of banana fiber and fabric manufacturer associated with manufacturing of fabric from renewable bast fibers like banana fiber.

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